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REPRODUCTION AND DEVELOPMENT OF THE HORN FLY, SIPHONA IRRITANS (L.) (DIPTERA:MUSCIDAE)

A DISSERTATION
SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF MASTER OF SCIENCE

FACULTY OF AGRICULTURE
DEPARTMENT OF ENTOMOLOGY

by

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REPRODUCTION AND DEVELOPMENT OF THE HORN FLY, *SIPHONA IRRITANS* (L.) (DIPTERA:MUSCIDAE)

ABSTRACT

The percentage hatch and pupation of Pincher Creek horn flies is significantly better than those from the Lethbridge area reared at the same temperature. The effect of low temperatures on the immature stages indicates that, in spite of this, a lower number of flies per host animal can be expected in the foothills than near Lethbridge.

In Alberta, *S. irritans* normally overwinter as puparia in arrested development. This state ended by mid-winter when puparia were reared and maintained at 18°C. Arrested development may be due to the effect of photoperiod on the unlaid egg or on the adult of the previous generation. Some overwintering takes place in the late larval stage, probably as a direct result of low temperature rather than of any arrest of development. Puparia in arrested development are killed by a period of two weeks at -20°C.

Puparia in all of the areas under study were parasitized by an undescribed species of *Phygadeuon* (Hymenoptera:Ichneumonidae).

PREFACE

The author wishes to express his thanks and appreciation to the following people for their suggestions and criticisms in the preparation of this thesis: Professor B. Hocking, Department of Entomology, University of Alberta; Mr. W. O. Haufe, Officer in Charge, Livestock Insect Section, Science Service Laboratory, Lethbridge, and Dr. G. E. Ball, Department of Entomology, University of Alberta. Thanks are extended also to the Systematic Unit, Ottawa, for identifying the horn fly parasites; to the Division of Entomology, Science Service, Ottawa, for permission to use data presented in this thesis; to members of the staff of the Livestock Insect Section, Science Service Laboratory, Lethbridge, for the help they gave in this project.

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REPRODUCTION AND DEVELOPMENT OF THE HORN FLY, *SIPHONA IRRITANS* (L.) (DIPTERA:MUSCIDAE)

I INTRODUCTION

The field investigations described in this thesis were conducted in the areas of Lethbridge, Pincher Creek, and Tod Creek in southern Alberta. The laboratory aspects were conducted at the Livestock Insect Laboratory at Lethbridge. The purpose of the research was to gain further knowledge of the life history and habits of *Siphona irritans* (L.), a serious pest of cattle, commonly known as the horn fly. This information will be useful in the establishment of a permanent colony of horn flies which may be used in control studies.

II MATERIALS AND METHODS

A. MATERIALS

Adult horn flies and fresh cow dung were collected at three locations in southern Alberta. The first was a flood plain of the Oldman river near Lethbridge which was used as pasture for a herd of beef cattle. The second location was a dairy farm one and one half miles east of

Pincher Creek, and the third a ranch at Tod Creek. The altitude in the Oldman river valley is about 2900 feet above sea level. That at Pincher Creek is about 3700 feet and that at Tod Creek about 4800 feet above sea level. (Figures 1 to 6 inclusive)

A cage, covered with metal window screening and having dimensions of six feet each way, was set up at each location in 1954. The floor of each cage was made of three-quarter inch exterior plywood. Field rearing was carried out in a two foot by two foot by four foot weather screen set on the floor of each cage. A thermohygrograph recorded temperature and humidity in each weather screen. In 1955 a smaller cage, reduced to four feet by four feet by six feet, was used so that it could be transported more easily.

Laboratory rearing was accomplished in constant temperature cabinets at 18°C., 24°C. and 30°C. at the Livestock Insect Laboratory at Lethbridge.

Both field and laboratory material was reared in 200 x 65 mm. enamelled metal pudding pans.[*]

[*] (Figures 7 and 8)

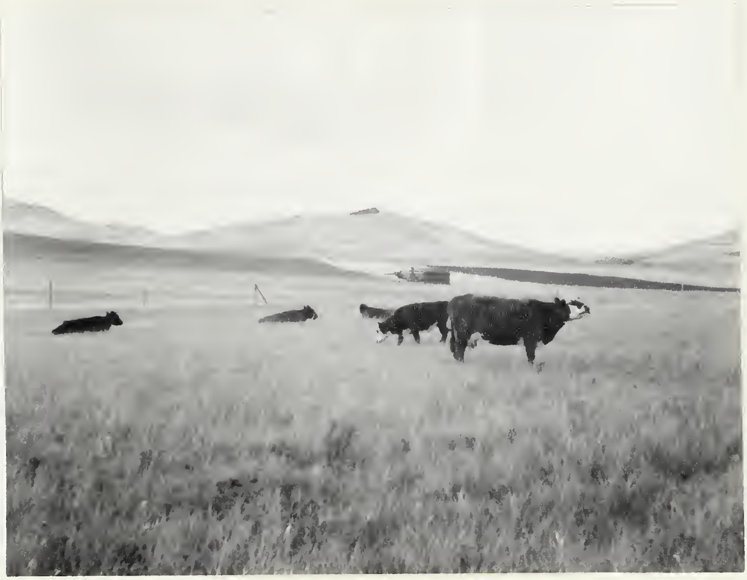

Fig. 1 Pasture and terrain near Tod Creek.

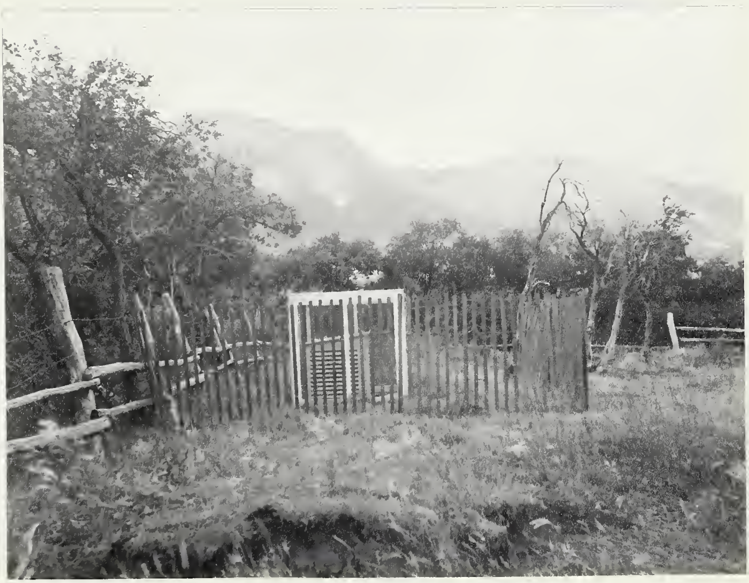

Fig. 2 Field rearing site and terrain near Tod Creek.

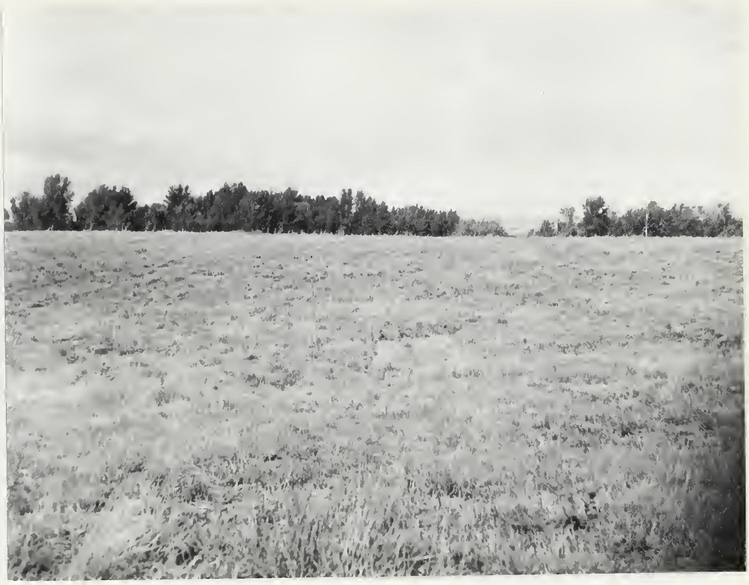

Fig. 3 Pasture near Pincher Creek.

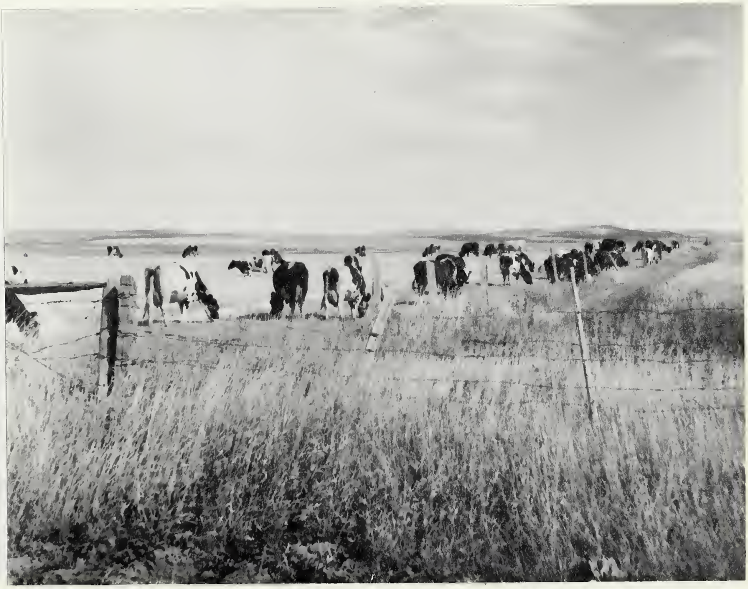

Fig. 4 Dairy herd near Pincher Creek.

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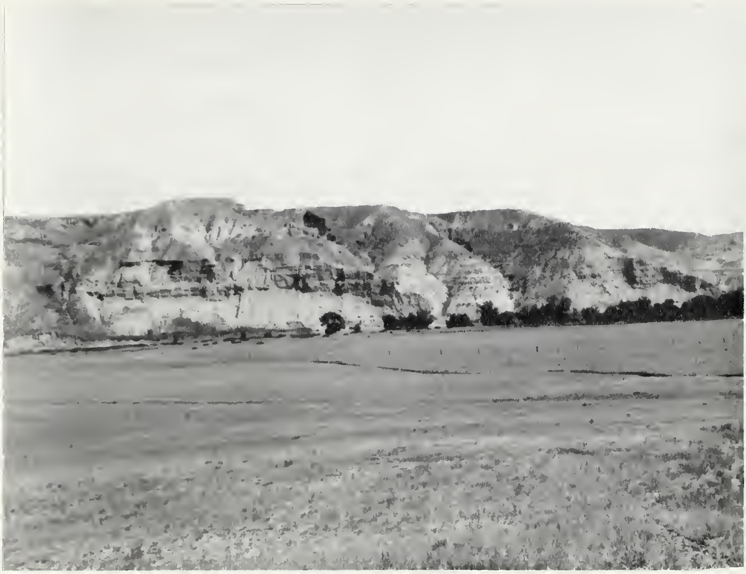

Fig. 5 Pasture and terrain near Lethbridge.

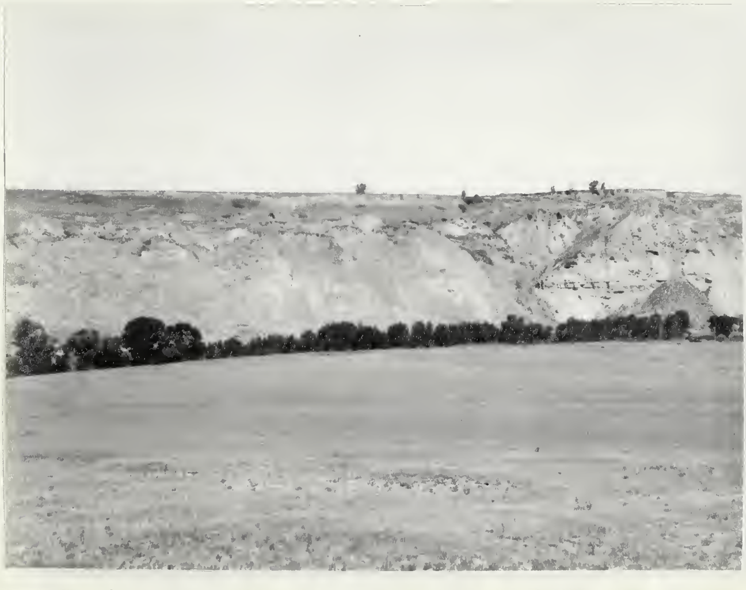

Fig. 6 Pasture and terrain near Lethbridge.

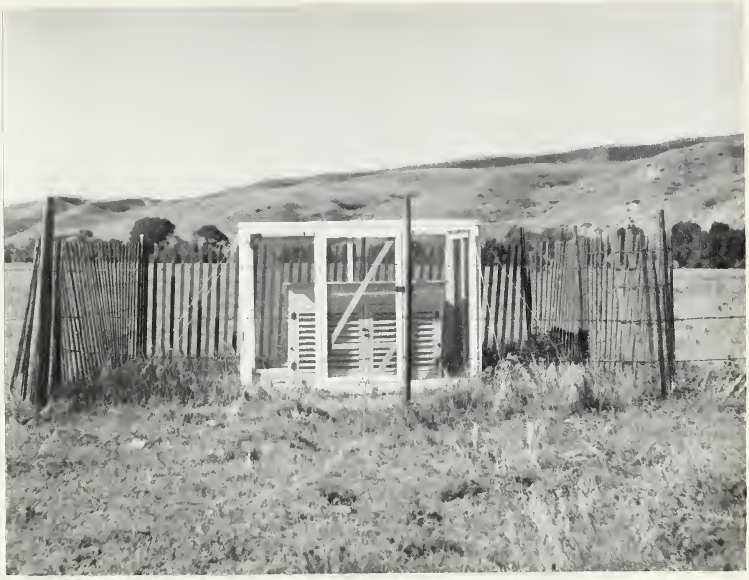

Fig. 7 Field rearing station.

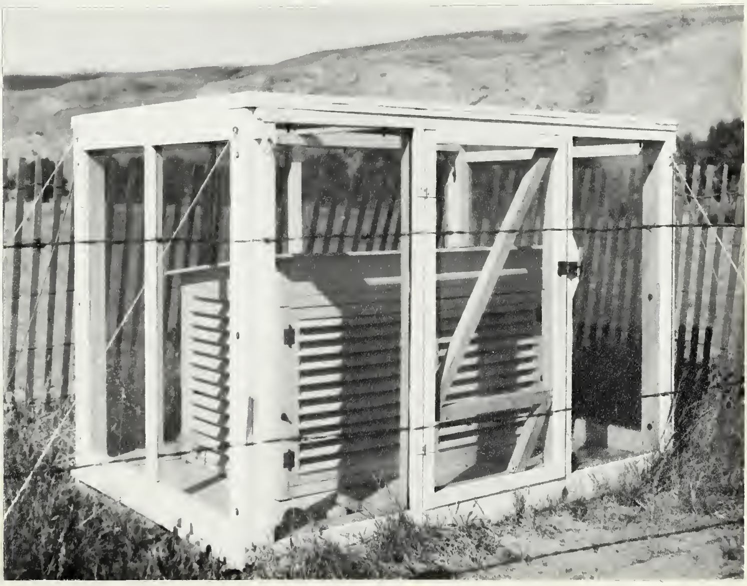

Fig. 8 Close-up of field rearing station.

B. METHODS

Rearing work at each location began when horn fly numbers were high enough to permit the collection of adequate numbers of eggs. Wild flies were captured weekly at each location by sweeping them from the backs of cattle with an insect net and transferring them to Erlenmeyer flasks. When a number of eggs had been laid on the sides of the flasks, the flies were transferred to another flask. The eggs were rinsed out of the flasks with water which was sucked off through a Buchner funnel. One and one half to two inches of fresh cow dung were put in an enamelled metal pudding pan, a square of moistened filter paper was placed on the dung, and 100 normal appearing eggs were placed on this. A fine, moistened, squirrel-hair brush was used to transfer the eggs to the filter paper. Cultures were made up in duplicate to be placed at each of the rearing temperatures. In previous attempts at rearing, eggs exposed to room humidity dried out and would not hatch. Saturation on the other hand killed the young larvae soon after hatching. The most satisfactory humidity was found to be just below saturation. This

condition was obtained by partially covering each rearing dish with a glass plate. The surface area covered varied from two-thirds to three-quarters of the total, depending on the condition of the dung, and on the temperature. Hatches of eggs obtained were as high as 100 per cent in 1954, and 97 per cent in 1955. (Page 8a here)

Time of pupation was determined by examination of the rearing medium. Puparia were separated from the dung by a flotation process. Newly pupated horn flies do not float on water and a waiting period of two to five days, depending on the temperature, is necessary before separation can be carried out. In the field, the medium was broken up into small pieces and put into a one gallon battery jar containing about two quarts of water. A short period was allowed for the material to soften, after which it was further broken up by vigorous stirring with a small wooden paddle. The puparia were skimmed from the surface with a small piece of metal screening as the stirring progressed. This method of extraction was satisfactory in the field but was found to be too slow for the laboratory. A Waring Blendor was used to speed up the process. The material was broken up and put into the bowl of the Blendor. Water

When the eggs hatch, the young larvae crawl off of the filter paper and onto the surface of the dung. Larval respiration is through the posterior spiracles which remain dry and are held above the surface of the semi-fluid medium. As a crust is formed on the surface of the dung, the growing larvae tunnel under this crust. These tunnels are extended downward as further drying permits, and may extend to the bottom before the mature larvae pupate. When time for pupation approaches, the larvae migrate to the drier parts of the dung, near the surface and along the sides. In exceptionally wet samples they have been observed to pupate directly on the surface.

was added and the Blendor operated at slow speed to break up the lumps. The resulting mixture was poured into a large flat metal pan and more water added. The puparia were skimmed from the surface while stirring and transferred to a smaller pan of clean water. This last step was necessary to remove the last of the rearing medium from the puparia. The speed of the Blendor was adjusted as required by operating it through a voltage regulator.

The puparia were removed from the water and placed on filter paper in a Syracuse watch-glass. The watch-glass was placed in a lantern globe standing in a flat 9 cm. petri dish cover. The lantern globe top was covered by marquisette and a pad of moistened cellucotton. The lantern globes, containing the puparia, were then returned to the temperature at which the puparia had been reared.

The flies were allowed to emerge and die in the lantern globes. When all were dead, they were removed, sexed, and counted. The puparia were then examined to determine pupal mortality and to check for parasites. Any living puparia were removed to small shell vials and stoppered with absorbent cotton. The vials were then put into a wide mouthed storage jar

covered with marquisette and moistened cellucotton, and returned to the rearing temperature.

III GEOGRAPHICAL DISTRIBUTION

The horn fly was first described by Linnaeus in 1758 (Bezzi, 1907). It was known in southern France in 1830 (Riley, 1889a; Smith, 1889) and was introduced into North America between 1884 and 1886. By 1892 it had spread across most of Canada and the United States (Marlatt, 1910). The first report of its occurrence in Canada was made by Fletcher in 1892. It is now found from coast to coast in Canada, and at least as far north as Gadsby in Alberta (latitude 52° 20' N.). I do not believe that the horn fly overwinters in the vicinity of Edmonton, but that it may occasionally be brought into the area by cattle from the south.

The name "horn fly" was given to the insect by ranchers and farmers when it first appeared on this continent because of the habit of clustering on the horns of cattle.

IV HABITS OF THE ADULTS

A. RESTING AND FEEDING

The horn clustering habit has been observed on several occasions but is not common in southern Alberta. Horn flies are easily recognized on cattle through their habit of clustering in patches in their characteristic head downward attitude. The fly is about half the size of a house fly, and is dark in color, appearing almost black on the host.

This insect is a serious pest of cattle in southern Alberta. It is found in the southern prairie region and westward into the valleys of the mountains.

All observers agree that the horn fly is an obligate blood-sucking parasite of cattle. It remains on the host night and day in the open and in buildings. Observations in southern Alberta indicate that the flies are more numerous on bulls than on cows. It has also been noticed that spring calves will have very few flies on them until late in the summer, in spite of the fact that their mothers may be carrying a high population. The

flies rest mainly on the backs of the animals when the weather is cloudy or cool. In warm sunny weather their position depends on the temperature. At temperatures up to 19°C. the preferred location is the back, but at temperatures of 26°C. to 29°C. they are always on the belly and shady parts of the animal (McLintock and Depner, 1954). Flies that are disturbed when they are clustered on the underparts fly up and land anywhere on the host. However, if they are then left undisturbed for a few minutes, they return to the shady underparts.

The resting position of a horn fly on its host is normally head downward. The proboscis is held parallel to the longitudinal axis of the fly's body and the wings are slightly spread. When feeding, the fly burrows among the hairs in the opposite direction to the lie of the hairs (Bruce, 1940, 1942; Hammer, 1942). The wings are slightly elevated and held out at an angle of 60° to the body (Riley, 1889a, b; Marlatt, 1910). Feeding usually takes place in an area of the cow's body on which the hair is short or sparse.

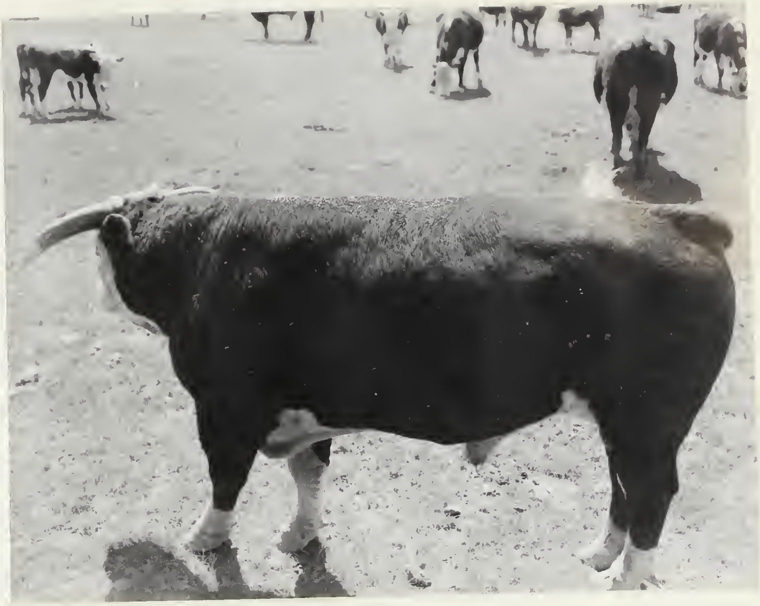

Fig. 9 Horn flies on the back of a bull.

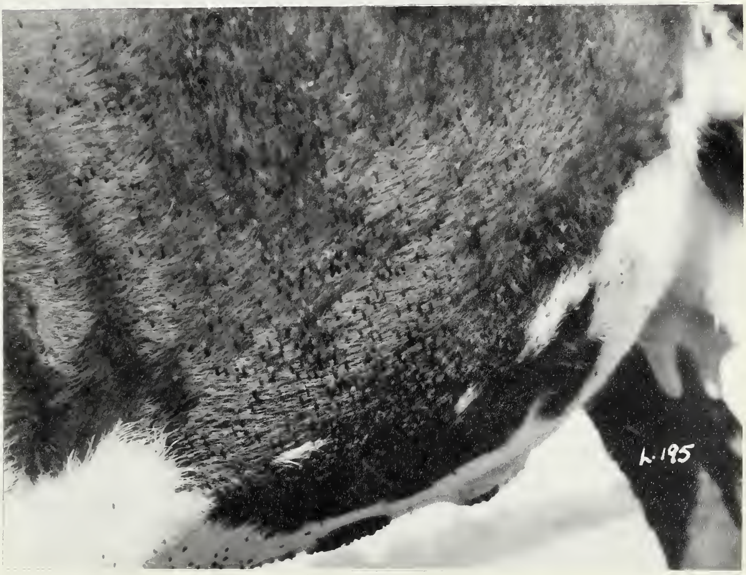

Fig. 10 Horn flies on a cow.

The number of horn flies per animal varies with the region and the year. In some years the number of flies is relatively low throughout the season. In other years the number per animal reaches several thousand. The spring of 1955 was such a season. The population of horn flies at Lethbridge reached its peak at about the middle of July. The bull in a herd of beef cattle near Lethbridge was found to have a population of about 10,000 flies. Cows in the same herd had several thousand flies per animal at this time. One cow was observed with a foot-wide band of closely clustered horn flies completely around her. During this period the cattle in this herd did very little daytime feeding. Most of their time was spent in the shelter of the brush and trees that border the Oldman river.

B. MATING HABITS

Little is known of the mating habits of horn flies. Bruce (1940, 1942) states that mating has been observed as early as two days after emergence. He does not say how the age of the flies was

determined or where mating took place. Hammer (1942) believes that prominent objects are the sites chosen. The writer has observed mating several times in southern Alberta. In each instance the site was the body of a cow, and mating took place after the cattle had been driven into a dairy barn. The light intensity in the barn at the time of each observation closely approached that found in the field at dawn and dusk. The temperature during one observation was 68°F. and the relative humidity was 53 per cent. The possibility that either a reduction in light intensity or an increase in humidity, or both, stimulate mating suggests that dawn or dusk are the times at which this act takes place in the field. Temperatures in southern Alberta, particularly in the foothills region where the observations were made, are much more favorable for insect activity at dusk than at dawn. Since horn flies are known to leave the host only to deposit eggs, it seems certain that the place of mating is always on the host. Experiments at Lethbridge (McLintock and Depner, 1954) have shown that horn flies are stenogamous and that mating takes place on the third day after emergence.

The rate of ovary development of laboratory-reared horn flies confined in a screen cage on a cow's back varied. The ripe oocyte has a length of 1.1 to 1.2 mm. Oocytes measured from 0.3 to 0.5 mm. at the end of three days and 0.4 to 1.2 mm. at the end of four days. In horn flies each ovary contains 12 ovarioles and the lowest oocytes develop synchronously. In general, only one oocyte in an ovariole develops at a time. The indications are that up to twenty four eggs may be laid at one time. In Alberta the eggs are laid under the cattle dropping or on the grass beneath it immediately after it is passed. If the cow is standing still while defecating, no horn flies arrive at the dropping until she moves. The flies alight on the surface and quickly disappear under the edges where they remain for up to ten minutes. Reports from the eastern United States (Riley, 1889) indicate that the eggs are laid on the upper surface of the dropping. It is possible that such a site is satisfactory under the conditions of higher humidity and less intense sunshine prevailing in the eastern parts of Canada and the United States. Experiments at Lethbridge in

1952 and in 1955 show that horn fly eggs laid on the upper surface of droppings in southern Alberta fail to hatch because of intense radiation and low relative humidity. It has been proven at the Lethbridge laboratory and by others (Larsen, 1943) that a very high relative humidity is required for the eggs to hatch. Furthermore, it has been found that eggs on the surface, even though artificially protected from desiccation, are very vulnerable to attack by the many other insects abounding in and on the droppings. *Paregle cinerella* Fall. (Diptera: Muscidae) lays its eggs in the surface of droppings in southern Alberta, but these eggs are protected from desiccation and predators by being pushed down into the dung until only a small portion of one end remains visible.

V. DEVELOPMENT OF THE IMMATURE STAGES

A. HATCHING OF THE EGGS

Melvin and Beck (1931) and Melvin (1934) have determined incubation periods for *S. irritans* eggs for several constant temperatures. The average at 77°F. was 19 hours and 39 minutes. The incubation period

decreased with increasing temperature until it averaged 11 hours and 20 minutes at 94°F. No eggs hatched at 104°F. The observations of Thomsen (1938) and Larsen and Thomsen (1941) agreed with these for the most part. They found that eggs would hatch at 38 to 39°C. but that the larvae quickly died at this temperature. Any temperature above 35°C. was found to have a harmful effect. The average incubation periods of horn fly eggs at Lethbridge from two years of rearing were 50 hours, 22 hours, and 18 hours at temperatures of 18°C., 24°C., and 30°C. respectively. The eggs were very susceptible to freezing temperatures, and were all killed at 0°C. Temperatures within the normal range found in the summer in southern Alberta had very little effect on the percentage hatch (see Appendix). Variation in the viability of eggs from the three regions under study was discovered. The data in Table 1 show that the percentage hatch of eggs from Pincher Creek is consistently higher than that of eggs from either Lethbridge or Tod Creek kept at the same temperature. Statistical analysis of the differences indicates that eggs from Pincher Creek have a significantly

Table 1.

Percentage hatch of horn fly eggs

Area	No.* of colonies	Rearing temperature						Field	
		30°C.		24°C.		18°C.			
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Lethbridge	15	77.9	± 13.2	73.4	± 14.4	74.3	± 10.7	74.8	± 11.4
Pincher Creek	12	83.5	± 10.5	85.4	± 7.0	87.5	± 5.2	83.2	± 8.1
Tod Creek	13	79.4	± 4.45	77.4	± 17.9	78.6	± 14.2	77.2	± 11.2

Each*Colony consists of two replicates.

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higher hatch (P = 0.02) than do eggs from Tod Creek when both are reared at 30°C. The percentage hatch of Pincher Creek eggs is significantly higher than that of Lethbridge eggs, when both are kept at 24°C., (P = 0.02) and at 18°C., (P = 0.01). The percentage hatch of eggs from Tod Creek falls between that of eggs from Lethbridge and Pincher Creek at both laboratory temperatures and under field rearing conditions.

B. DEVELOPMENT OF THE LARVAE

In nature horn fly larvae develop only in cattle dung. The condition of the dung is important to their development. The larvae die or form undersized, nearly transparent puparia if the dropping dries out before larval development has been completed. These small puparia often produce active flies that are only one half the size of a normal horn fly. The same effect can be seen in the field when temperatures approach the lower developmental threshold.

Investigations at Lethbridge at 18°C., 24°C., and 30°C., have shown that the duration of the larval period at these temperatures is 10.5, 5.6 and 3.7 days respectively. These results agree

reasonably well with the figures given by other authors as quoted in McLintock and Depner (1954). It was found that the time required for all of the larvae in one culture to pupate was spread over a period of from 2 days at 30°C., to 5 days at 18°C. **(Table II)**

Larval mortalities at 24°C. and 30°C. in the laboratory showed the same variation for the three localities as did the percentage hatch of the eggs. The percentage of larvae pupating at 24°C. was significantly higher in material from Pincher Creek ($P = 0.01$) than in material from Lethbridge. **(Table III)**

Field mortalities of larvae from the three localities indicate that horn fly larvae are very susceptible to low temperatures. The percentage of larvae in, 15 colonies, pupating in the field at Lethbridge was 58.8 ± 24.0.* The overnight low temperatures for the area never fell below 40°F., and went as high as 60°F. during July and August (see Appendix). The mean overnight low for the period was about 50°F. Pincher Creek had a low of 36°F. for this period and the highest overnight low was 49°F. The mean overnight low for this area was about 41°F., and the pupation was 46.2 ± 27.4 per cent. The temperatures at Tod Creek were even more extreme. The lowest temperature for July and

* Refers to standard deviation here and in any following figures.

Table II

Larval Development, Days

Area	No.* of colonies	Rearing temperature					
		30°C.		24°C.		18°C.	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Lethbridge	15	3.7	± 0.5	5.6	± 0.7	10.5	± 1.6
Pincher Creek	12	3.7	± 0.8	5.6	± 0.6	10.3	± 0.9
Tod Creek	13	3.6	± 1.6	5.5	± 0.8	10.5	± 1.1

Each *Colony consists of two replicates.

Table III

Percentage Larvae Pupating

Area	No. * of colonies	Rearing temperature						Field	
		30°C.		24°C.		18°C.			
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Lethbridge	15	66.7	± 14.5	71.9	± 11.9	75.5	± 11.3	58.8	± 24.0
Pincher Creek	12	78.4	± 11.2	77.2	± 18.3	70.2	± 27.7	46.2	± 27.4
Tod Creek	13	72.2	± 22.6	74.7	± 18.1	61.5	± 21.7	14.4	± 12.1

Each*Colony consists of two replicates.

August was 30°F. The highest overnight low during the same period was 46°F., and the mean was about 37°F. Percentage pupation at Tod Creek was 14.4 ± 12.1. The susceptibility of horn fly larvae to low temperatures changes after feeding stops in the final instar. All feeding horn fly larvae are killed by freezing temperatures but those that are no longer feeding will withstand considerable frost. Summer cow droppings brought into the laboratory in winter have been found to contain living final instar larvae. (Development of these larvae to the pupal stage continues as soon as the temperature becomes sufficiently high.) The arrest of development in these larvae is entirely a function of low temperature, and development continues to the pupal state when temperatures become high enough to allow further development. Non-feeding horn fly larvae are easily distinguished from those that are still feeding. Shortly before pupation, the color of the larvae changes from a translucent white to an opaque yellowish color. This color deepens as puparium formation approaches.

C. PUPATION

The moisture requirements of puparia are lower than those of the larvae. In nature, prior to pupation, the larvae move downward and pupate in the dropping, or in the soil beneath the dropping. Riley (1889b) states that the puparium is formed in the ground beneath the dung. Mohr (1943) accepted Riley's statement but noted that he had reared a number that had pupated in the dropping. Hammer (1942) in Denmark, found the puparia more often in the ground beneath the dropping than in the dropping. In the foothills region of southern Alberta, they are found in the droppings, and on or in the soil beneath the droppings (McLintock and Depner, 1954).

The duration of the pupal period of horn flies at laboratory temperatures of 18°C., 24°C., and 30°C., was found to be about 13.5, 7, and 5 days respectively. Pupal mortalities in the laboratory were considerably lower at 18°C. than at either 24°C. or 30°C. Here again a greater viability of the Pincher Creek population was shown by a significantly lower pupal mortality (P = 0.02) than Lethbridge puparia. Pincher Creek

Table IV

Pupal Development, Days

Area	No.* of colonies	Rearing temperature					
		30°C.		24°C.		18°C.	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Lethbridge	15	4.7	± 0.7	6.8	± 1.3	13.6	± 1.0
Pincher Creek	12	5.2	± 0.7	7.6	± 1.2	13.2	± 1.7
Tod Creek	13	5.2	± 0.4	7.1	± 1.1	13.6	± 1.7

*Each Colony consists of two replicates.

Table V

Percentage Pupal Mortality

Area	No.* of colonies	Rearing temperature						Field	
		30°C.		24°C.		18°C.			
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Lethbridge	15	22.3	± 18.7	25.4	± 17.0	13.0	± 13.4	45.6	± 22.4
Pincher Creek	12	24.3	± 18.6	26.9	± 22.2	5.6	± 6.7	49.1	± 26.6
Tod Creek	13	23.8	± 17.3	26.0	± 16.7	13.6	± 13.4	77.6	± 18.5

Each* Colony consists of two replicates.

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and Tod Creek had a difference in mortalities approaching significance at the probability level of 0.1. The variation in environmental temperatures of the three regions produced a variation in the mortality rate of field-reared puparia similar to that of the larvae. Lethbridge, which had the highest overnight temperatures, had the lowest pupal mortality at 45.6 ± 22.4 per cent. Pincher Creek was next with a pupal mortality of 49.1 ± 26.6 per cent. Tod Creek, the area of the lowest overnight temperatures, had the highest mortality in the field-reared puparia at 77.6 ± 18.5 per cent. **(Tables IV, V, & VI)**

D. OVERWINTERING

The overwintering habits of horn flies vary with the latitude. In the low latitudes of the southern United States (Bruce, 1940) and the Hawaiian Islands (Marlatt, 1910) the flies are said to continue to breed throughout the winter months. Marlatt (1910) and Smith (1890) claimed that overwintering in the area around New Jersey and Washington, D.C., is in the pupal or adult

Table VI

Time from Oviposition to Adult Emergence, Days

Area	Rearing temperature					
	30°C.		24°C.		18°C.	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Lethbridge	9.4	± 0.9	13.3	± 1.4	25.6	± 1.0
Pincher Creek	9.9	± 0.7	14.1	± 1.3	25.2	± 1.9
Tod Creek	9.7	± 0.4	13.5	± 1.3	25.8	± 1.9

stage. In colder regions overwintering is in the pupal stage (Bruce, 1940; Fletcher, 1892; Hammer, 1942; Mohr, 1943; Winn, 1893).

Evidence gathered at Lethbridge suggests that horn flies in southern Alberta overwinter in the final larval instar and in the pupal stage (McLintock and Depner, 1954). The more common is the pupal stage. Larval overwintering appears to be the result of temperatures falling too soon to allow pupation. Overwintering third instar larvae continue to develop to the pupal stage if brought into the laboratory. A tendency to enter a state of arrested development appears in horn fly puparia reared from eggs laid after mid summer. This tendency appeared in the field and at 18°C. in the laboratory in puparia from eggs laid in the fourth week of July. At 24°C. and 30°C., arrested development did not appear until the first and third weeks of September respectively.

Horn fly cultures were reared in the laboratory under constant conditions throughout the season. All material was brought through to emergence of the adults in total darkness. Since

Table VII

Dates of Appearance of Arrested Development in the Pupal Stage

Area	Field	Laboratory		
		18°C.	24°C.	30°C.
Lethbridge	August 15	July 25	September 6	--
Pincher Creek	July 27	July 27	September 7	September 19
Tod Creek	July 28	July 28	September 8	--

the rearing conditions did not vary, it is evident that the effect of some external factor on the adult or unlaid egg is responsible for the appearance of arrested development.

The data in Table VII indicate that temperature plays an important part in the actual appearance of arrested development after the ability to enter this state has been established. It is evident that some factor other than temperature is responsible for the establishment of this ability. It was thought for a time that the diet of the larvae might in some way have an effect, and an experiment to test this hypothesis was set up. It was realized that the diet of a cow changes throughout the year as the state of vegetation changes. The composition of the faeces, which is the food of horn fly larvae, must also change. To test the effect of this, cow faeces were collected and quick frozen every month for a year. The following year horn flies were reared simultaneously in dung from each month throughout the horn fly season. No arrested development appeared in puparia reared in the dung that had been frozen until it also appeared in those

reared in fresh cow dung which was used as a control. This experiment proved that the food of the larvae, which varied greatly in moisture content and consistency, had no effect on the appearance of arrested development.

The number of generations of horn flies in a season has no bearing on the appearance of the arrested state. The rate of development of the immature stages is directly dependent on the rearing temperature. The data in Figure XI show that a different number of generations have developed in each area at any given time. In spite of this fact, arrested development appeared in puparia from the three regions from eggs laid in the same week at both 18°C. and 24°C. The fact that this stage appeared in the field at Lethbridge three weeks later than at Pincher Creek and Tod Creek is an indication of the difference in developmental conditions of these areas. It has been established that neither the food of the larvae nor the rearing temperature brings on the initial tendency to enter the state of arrested development in horn flies. The number

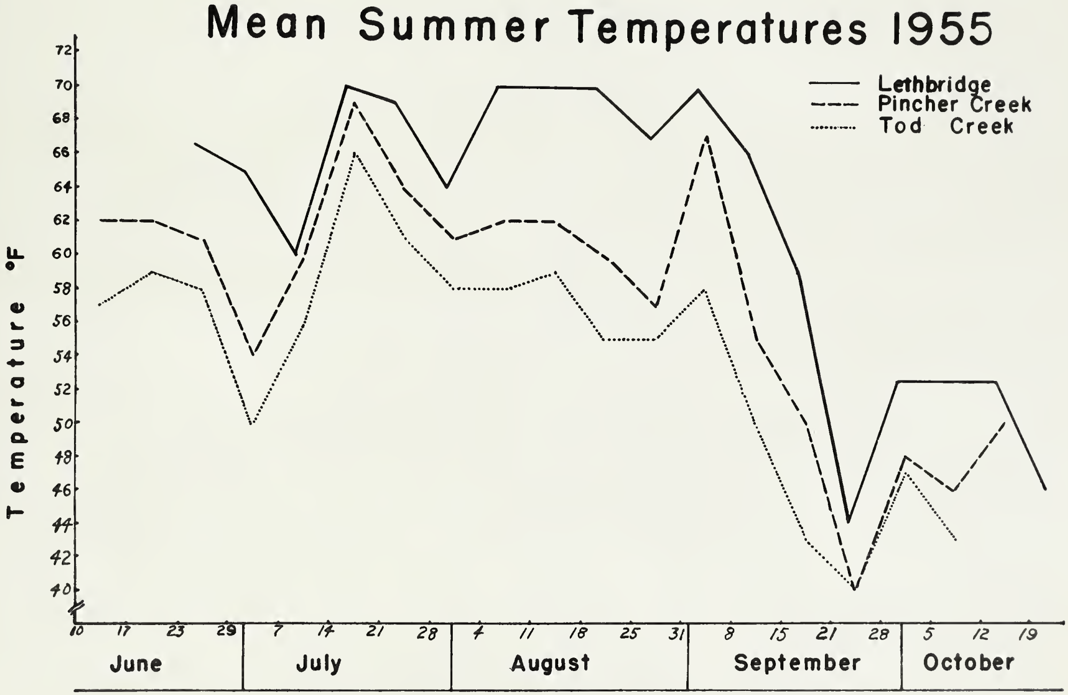

Fig. 11 Comparison of mean summer temperature at Lethbridge, Pincher Creek and Tod Creek in 1955.

of generations of flies in the season is also ruled out. It is evident that some factor or factors in the environment are responsible for the physiological conditions that lead to the appearance of this state. This factor must be the same in each area at any time. Temperature, moisture, and radiation conditions are different for each area. Photoperiod is the only factor that is alike in the three regions. Furthermore, the fact that all rearing is done in the absence of light precludes any effect in the larval stage. The only conclusion one can come to is that the effect of photoperiod on the adult of the previous generation or the unlaid egg brings about the physiological conditions leading to a state of arrested development. The actual appearance of this state is then determined by the environmental temperatures to which the larvae are exposed. Only a small percentage of puparia exhibit the state of arrested development when it first appears in a culture. As the season progresses more and more puparia are found to be in this state until 100 per cent are in arrest. At 18°C., puparia reach loo per cent arrest in development in five weeks. At 24°C. and 30°C. the number showing arrested development

increases as the season progresses. One hundred per cent arrest at these temperatures has not been obtained because the natural population of horn flies is killed by autumn frosts and the source of eggs for rearing eliminated.

Early season horn flies reared at 18°C. have a pupal period of 13.5 days. Earliest emergence of adults from puparia in arrest was seven weeks or 50 days following pupation. The majority of the flies from puparia in arrested development emerged at twelve to eighteen weeks after pupation. A small but increasing number emerged in the 7 to 12 week period and a few emerged as late as 24 weeks after pupation. An interesting concept is brought out by this information. It can be seen that arrested development of horn fly puparia may not be an overwintering habit in the true sense of the word. Its main purpose appears to be the prevention of the emergence of flies from late season puparia when another generation would not be able to develop. The need for this state is ended when temperature conditions are such that further development is impossible. The state of arrested development comes to an end and further

dormancy is due to the effect of low temperature alone.

Puparia, varying in age from 13 to 17 weeks after pupation, were subjected to a series of low temperatures for a period of two weeks in an effort to determine the minimum lethal temperature. Temperatures as low as -15°C. had no adverse effect. All puparia subjected to a temperature of -20°C. were killed. The rate of emergence from arrested development for puparia kept at +5°C. to -15°C. did not change noticeably when they were returned to 18°C. Two weeks of low temperature therefore has no effect on the duration of the state of arrested development.

VI. PARASITISM OF THE PUPARIA

Parasites were found in field-reared puparia of Siphona irritans in each of the three areas under study. The parasite in each area was an undescribed species of the genus Phygadeuon, family Ichneumonidae. The identification was made by the Systematic Unit of the Division of Entomology. Only 0.2 per cent of puparia from Lethbridge were parasitized. Pincher Creek and

Tod Creek puparia had an average of 12.8 per cent and 7.1 per cent parasitism respectively. This parasite was also found infesting the puparia of Paregle cinerella Fall. which also breeds in cow droppings in southern Alberta. Although Phygadeuon is the only parasite of Siphona irritans observed in southern Alberta, the horn fly is attacked by other Hymenoptera in other parts of the world. Hammer (1942) states that he has reared "ichneumons" from horn flies, as well as from many other dung breeding flies. Marlatt (1910) says that horn fly puparia collected in the field in Hawaii were found to be parasitized by Spalangia hirta Haliday.

VII. SUMMARY& CONCLUSIONS

1. The appearance of Siphona irritans in North America and its present distribution in Alberta are discussed.
2. The habits of the adult flies are described and some idea of the numbers per animal is given.
3. Horn flies mate while on the bodies of cattle.

4. The egg laying habits are discussed and a comparison with oviposition sites in other localities is made. The preoviposition period and the number of eggs laid are mentioned and the observations at Lethbridge are compared with information found in the literature.
5. Investigation of mortalities of the immature stages of horn flies from Lethbridge, Pincher Creek and Tod Creek indicate that a more viable race of flies is found at Pincher Creek.
6. Duration of the egg, larval and pupal states at three laboratory temperatures are given. A comparison of the effects of three constant temperatures on the immature stages is made and the effect of field temperatures on populations in the three areas discussed.
7. A state of arrested development of the puparia of horn flies plays an important part in over-wintering. This state seems to be due to the effect of photoperiod on the adult or unlaid egg. The tendency to enter this state appears in puparia from eggs laid in the fourth week of July. A temperature of 18°C. favors entry of a higher proportion of the population into

arrested development than do 24°C. or 30°C. All flies from puparia in arrested development kept at 18°C. emerge from the seventh to the twenty fourth week after pupation. The greater number of flies emerge from twelve to fourteen weeks after pupation. The normal pupal period for horn flies reared at 18°C. is 13.5 days, while the earliest emergence from arrested development is 50 days after pupation.

The information obtained indicates that arrested development is ended by mid winter at the latest and that further overwintering is due entirely to low temperature.

This state is effective in preventing adult flies from emerging when the remaining season is too short to permit the development of another generation.

8. Horn flies in southern Alberta were found to be parasitized in the pupal stage by Phygadeuon sp. (Hymenoptera:Ichneumonidae).

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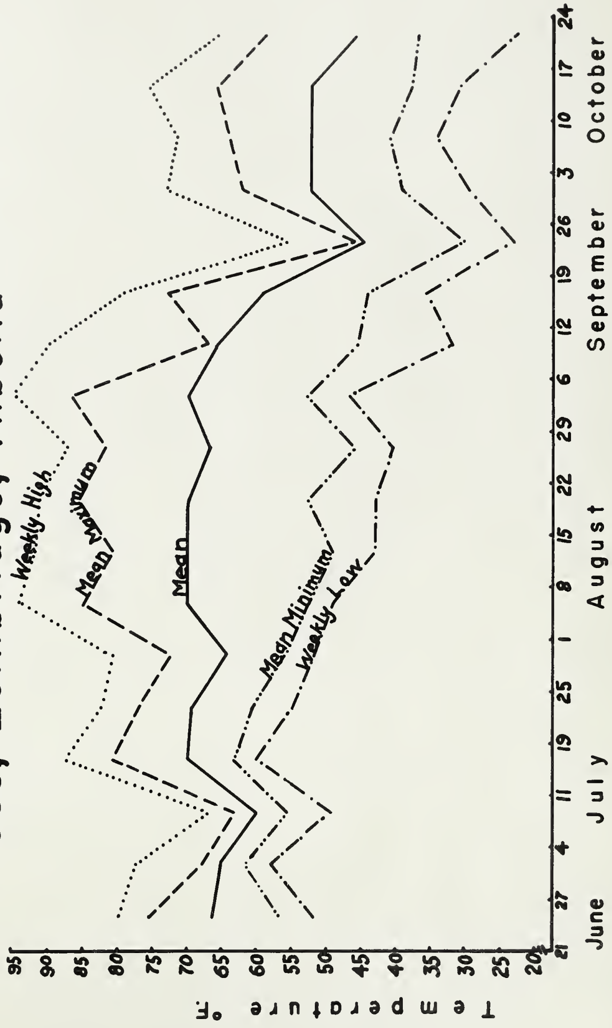
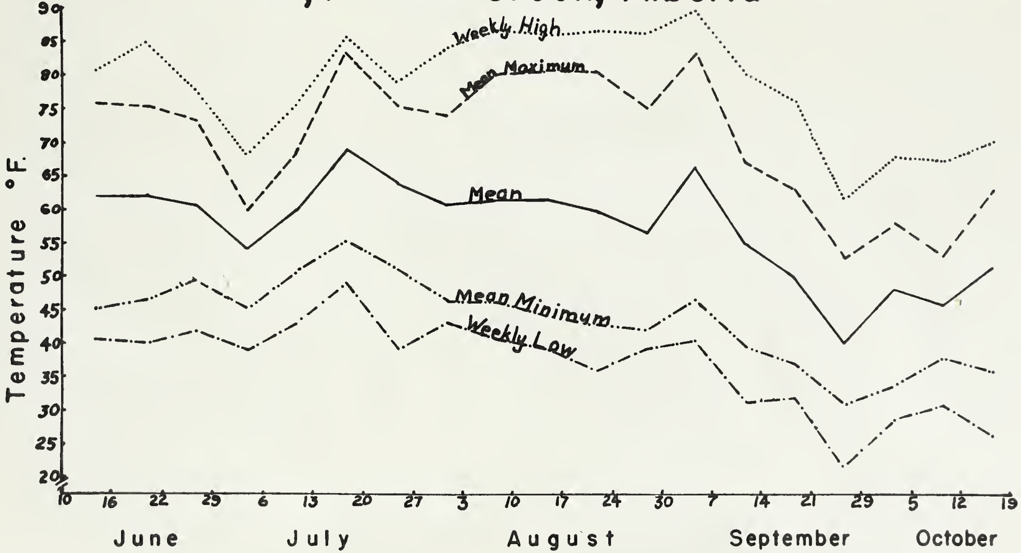
APPENDIX

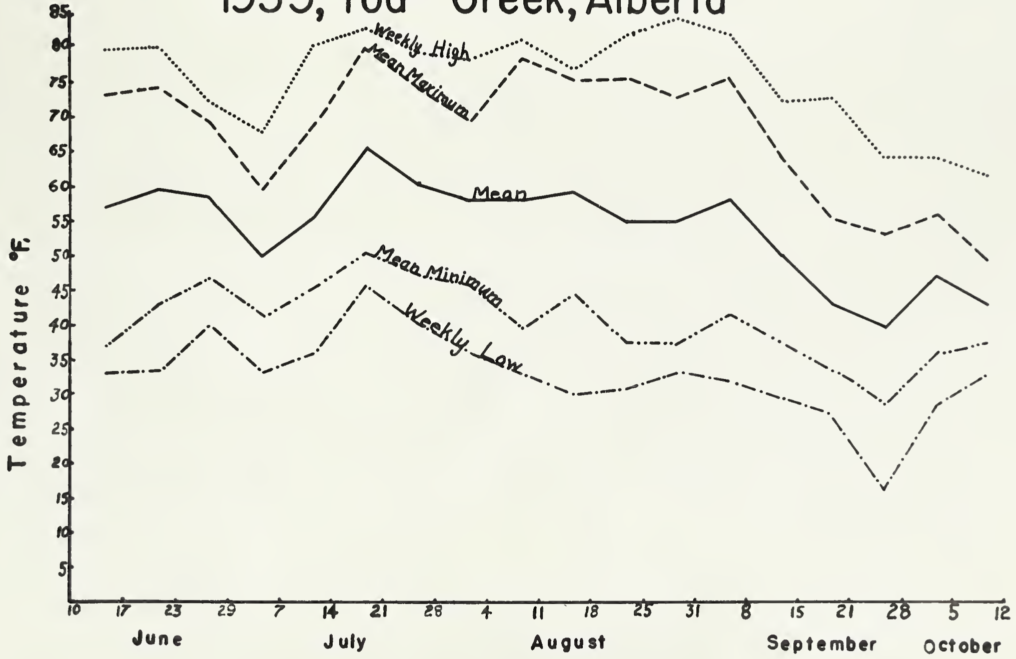


Temperature Record, June 21 to October 24, 1955, Lethbridge, Alberta

Temperature Record, June 10 to October 19, 1955, Pincher Creek, Alberta



Temperature Record, June 10 to October 12, 1955, Tod Creek, Alberta



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